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(54) Extra antenna element.

(57) The present invention relates to a method and an arrangement using an extra member (10) intended to be connected to the ordinary grounding plane system of an antenna (1) through a portion a the coaxial input terminal (4) sleeve (6) being present outside the case (2) of an apparatus. The extra member (10) is tuned in such a way that it preferably operates as an electrical quarter-wave radiator in a range at the upper limit of a designed operating frequency range, while the remaining effective grounding plane system of the antenna is preferably tuned to a frequency in a range at the lower limit of the intended operating frequency range, where, for instance, a portable radio telephone should operate, to in this way obtain an increased bandwidth and a reduced influence of immediate surrounding environment of the antenna of the portable equipment.

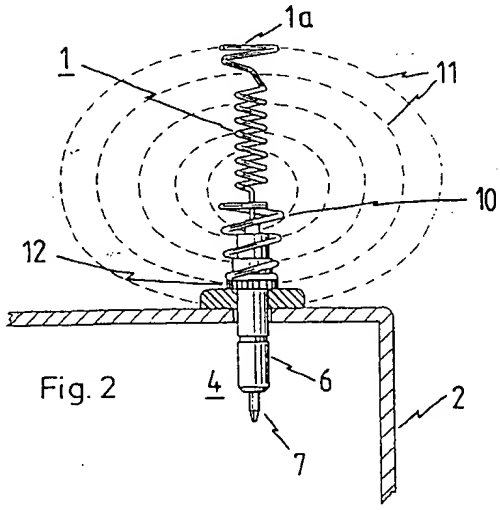

Fig. 2

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TECHNICAL FIELD

The present invention relates to a method and an arrangement utilizing said method to improve the efficiency and the bandwidth of an antenna, and particularly the present invention relates to a method and an arrangement to minimize the influence on the antenna, for instance, by a hand of a user holding a pocket telephone provided with a compact antenna.

BACKGROUND OF THE INVENTION

An antenna for a pocket telephone is usually formed as a short antenna member which electrically corresponds to a length of a half-wave or a quarter-wave at the operating frequency of said pocket telephone.

The Swedish published patent application SE 468 917, having the same assignee as the present application, is disclosing an example of such a compact miniature antenna having essentially a rectangularly shaped current distribution between the base and the top and which member is quite suitable as an antenna for a pocket telephone.

However, a remaining problem for such an antenna to operate fairly satisfactory is that it generally demands the presence of a grounding plane to form an efficacious antenna system. Normally, if the case of the pocket telephone is conducting, that should constitute a grounding plane for the antenna. Anyhow this has the drawback that there might be troublesome uncontrolled circulating currents in the equipment, which currents also may have an injurious effect on the possibility of the antenna system to properly radiate radio energy.

An common way therefore is, like as was demonstrated in the above published patent application SE 468 917, to make a particular, usually also tuned, grounding plane connected to the antenna to form an antenna system, and to have this grounding plane insulated from the rest of an eventually conducting structure of the pocket telephone. This grounding plane then must be placed immediately adjacent to the antenna itself, which is normally positioned at the top of the equipment and adjacent to the portion the user will put to his ear, but, as demonstrated in the published patent application, avoiding to bring down the grounding plane to the portion of the equipment which will be enclosed by the hand of a user. However, the hand and the ear will, for instance, influence the tuning of this grounding plane system and the antenna because a part of the irradiated energy by the field distribution in the antenna near field will be transferred to the equipment chassis and the designer therefore has little control of the grounding plane function, which thus will be dependent of the way a user holds the telephone.

In a document US-A-4 138 681 is disclosed an antenna for a hand-held radio transceiver including a first and a second element to minimize surface currents across the radio's body, thereby substantially eliminating power loss caused by absorption in the user's body. However this antenna has a size which is approximately 8 times larger compared to the antenna disclosed in the above referred Swedish published patent application SE 468 917.

Another document GB-A-2 141 878 discloses an antenna comprising a coaxial feeder to obtain good stability and bandwidth. However the antenna size will be increased by $\lambda/50$ which should correspond to an order of increase by 20 % in antenna size for an design according to said Swedish published patent application SE 468 917.

Therefore there is still a desire to attain an arrangement in connection with such an antenna for a pocket telephone, which as far as possible will reduce the influence on the general function of the antenna by the body of a user. Simultaneously there is a wish to be able to make the antenna as broadbanded as possible, to have the pocket telephone operating within a wider frequency range.

SUMMARY OF THE INVENTION

A first object of the present invention is, by means of a method and an arrangement utilizing said method, to attain an antenna, for instance for a pocket telephone, which is very much less sensitive to the proximity of a user.

An additional object by the method and the device according to the present invention is to attain an antenna having a radiation impedance which will be less dependent of the unit onto which the antenna is mounted, whereby is achieved a generally better average efficiency of the antenna.

Another further object by the method and the arrangement according to the present invention is to attain an antenna which generally demonstrates a radiation impedance having a small variation within a predefined operating frequency range, in other words an improved bandwidth of the antenna, so that a wider operating frequency range will be available for a transmitting equipment connected to the antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with additional objects and advantages thereof, may best be understood by making reference to the following description taken together with the accompanying drawings, in which:

Fig. 1 demonstrates an antenna according to the state of the art mounted onto a portable equipment and having a part of its surrounding electric field indicated;

Fig. 2 demonstrates an antenna of Fig. 1 including a member according to the present invention being mounted onto a portable equipment and having a part of its surrounding electric field indicated;

Fig. 3 is a Smith diagram and a plot of the standing wave ratio for the antenna according to Fig. 1 when experiencing no external influence

Fig. 4 is a Smith diagram and a plot of the standing wave ratio for the antenna according to Fig. 1 when experiencing an external influence by the hand and head of a user;

Fig. 5 is a Smith diagram and a plot of the standing wave ratio for the antenna having an extra member in accordance to the present invention according to Fig. 2 when experiencing no external influence; and

Fig. 6 is a Smith diagram and a plot of the standing wave ratio for the antenna having an extra member in accordance to the present invention according to Fig. 2 when experiencing an external influence by the hand and head of a user.

AN ILLUSTRATIVE EMBODIMENT

Figure 1 demonstrates an antenna 1 for an equipment in the shape of a handheld mobile telephone according to the state of the art. Associated with a case 2 of the equipment, onto which the antenna is mounted, there is a built-in grounding plane system (not shown) which above the equipment chassis is connected to an antenna coaxial sleeve 6. In the illustrative embodiment the antenna 1 consists of an antenna element made as a vertical helix, preferably constituting a quarter-wave resonator for the operating frequency range of the equipment and which fundamentally has an essentially rectangular current distribution between the base and the top. The antenna element is connected to the equipment by a coaxial terminal 4, which together with an insulating washer 3 is inserted into the case 2. The central pin 7 of the coaxial terminal 4 is connected to the radio transceiver common output/input, while the other pole of the radio transceiver common output/input is connected to the outer sleeve 6 of the coaxial terminal 4 and is thereby connected to the equipment built-in grounding plane system, which normally is electrically insulated from the usually electrically conducting case of the apparatus. Additionally in practice the complete antenna device is embedded into a cover (not shown) of non-conducting material, for instance silicon rubber, to protect the antenna element.

In Figure 1 is additionally outlined dashed electric field lines 5 around the antenna element of an operating equipment. This radiation field is influenced greatly by the case 2 of the equipment and contributes to energy transfer to the case and will thus further contribute to the influence by the proximity of a user, for instance, when he holds the equipment and puts the apparatus to his ear.

Figure 3 demonstrates how the antenna impedance varies as a function of frequency partly in form of a conventional Smith diagram and partly by a plot showing the antenna standing wave ratio (SWR) for a frequency range of 200 to 2000 Mhz within which is found the antenna operating range 825 - 970 MHz. Figure 3 refers to the antenna of Fig. 1 when it operates without external influence. The antenna system then exhibits an acceptable frequency bandwidth and the standing wave ratios for three noted reference frequencies 825, 900 and 960 MHz within the operating frequency range are 1:1.73, 1:1.35 and 1:1.79 respectively, which represent acceptable values.

In the same way Figure 4 demonstrates a corresponding diagram when the equipment is being influenced by the hand and head of a user. For the three measuring points 825, 900 and 960 MHz are now achieved standing wave ratios which are 1:1.35, 1:2.13 and 1:4.09 respectively. Because of the proximity to the hand and head of the user the antenna bandwidth has decreased such that for instance the value at 960 MHz is no longer acceptable at all and the efficiency of the apparatus at the portion to the right of the operating frequency range has generally markedly deteriorated.

Figure 2 demonstrates in an illustrative embodiment the antenna 1 according to Figure 1 but provided with an extra member 10 according to the present invention. The extra member 10 has the shape of an upwardly directed open helix having in the illustrative embodiment about four turns. The lower end of the extra member is immediately above an insulating washer 3 connected to the coaxial terminal 4 outer sleeve 6, which is additionally connected to the equipment built-in grounding plane system. In the illustrative embodiment the sleeve 6 is provided with a flange 12 to which the extra member 10 is connected. This flange 12 in turn is resting against the insulating washer 3. The purpose of the extra member 10 is to raise the electric field around the

antenna element of an operating equipment such that less radiated energy will be transferred to the apparatus chassis, which is outlined by the dashed electric field lines 11 of Figure 2.

Figure 5 demonstrates how the impedance varies as a function of frequency for the antenna according to the present invention and shown in Figure 2. By analogy with Figure 3 and 4 this is shown in the form of a conventional Smith diagram and in part by a plot demonstrating the antenna standing wave ratio (SWR) for a frequency range 700 to 1100 Mhz within which the antenna operating range 825 - 970 Mhz is found. Figure 5 refers to the antenna of Fig. 2 when it operates without any external influence. The antenna system then demonstrates an excellent frequency bandwidth and the standing wave ratios for the three reference frequencies 825, 900 and 960 MHz within the operating range are about 1:1.4, 1:1.15 and 1:1.12 respectively, which indicates a good matching to the radio section of the equipment.

Figure 6 shows in the same manner as in Figure 5 a corresponding plot when the equipment is influenced by the hand and head of a user. For the three measuring points 825, 900 and 960 MHz are now obtained standing wave ratios which are 1:1.2, 1:1.9 and 1:1.9 respectively. Because of the proximity of the hand and head of a user the antenna bandwidth has been affected, but due to the extra member 10 according to the present invention this influence is substantially much less and the antenna still maintains a good matching. It will be verified according to the plot of the standing wave ratios that the ratio nowhere within the operating range exceeds 1:2 to be compared to the values which according to Figure 4 were measured for the antenna of Figure 1 when it was situated in a corresponding surrounding.

From the Smith diagram of Figures 3, 4, 5 and 6 it will be evident for a person skilled in the art how the total impedance of the antenna is distributed between a resistive component and a capacitive or inductive contribution, respectively. Also here by studying the Smith diagram of Figure 5 it is evident that according to the invention the extra member 10 is particularly favorably influencing the antenna element 1 impedance value generally aimed at over the operating frequency range.

In the preferred embodiment the extra member is preferably tuned to a resonance at or close to the antenna upper limiting frequency, while the built-in grounding plane system in a corresponding manner is tuned at or close to the lower limiting frequency of the antenna 1. According to the invention the extra member 10 may be made having a variety of different embodiments like for instance a straight coil or a helix or as a conical helix. Correspondingly the radiator corresponding to the antenna element 1 may of course have a variety of different embodiments familiar to a person skilled in the art. In the preferred embodiment is demonstrated an upwardly slightly conical helix having about four turns with a maximum diameter approximately corresponding to the diameter of the antenna top loop 1a while those skilled int the art may apply the method and the arrangement according to the present invention having a straight or a conical helix with more or less turns as a function of a desired operating frequency range without departure from the spirit and scope of the invention as set forth in the appended claims.

Claims

1. A method for improving efficiency and bandwidth of an antenna (1) at a portable equipment comprising a radio transceiver, e.g., in the shape of a pocket telephone, **characterized in** that the impedance and electromagnetic radiation field is influenced by the introduction of an extra conical helix shaped member (10) connected to the antenna grounding plane system, whereby is obtained a decreased influence of the antenna operation and its radiation field due to that a user is holding said portable equipment provided with said antenna.

2. The method according to claim 1, **characterized in** that the extra member (10) is resonantly tuned to a frequency within the operating frequency range of the radio station/pocket telephone, the resonance frequency of said member for instance is set near to the upper limiting frequency of the operating frequency range, while the rest of the antenna grounding plane system is resonantly tuned to a lower frequency within the frequency range in which said portable equipment is supposed to operate, whereby is obtained an increased bandwidth of the antenna system which is aimed at because the frequency limits of the antenna system impedance matching may be displaced by the influence of the adjacent external environment, said influence being strongly reduced by said extra member (10) and a scope for said influence being founded at the same time.

3. The method according to claim 1, **characterized in** that the extra member (10) is made as a coaxial screw shaped open coiled line or a helix at a lower end of said antenna (1) and being connected to a screen (6) at the antenna coaxial input terminal (4), the inductance of said extra member in cooperation with present

stray capacitances forming a resonance frequency corresponding to a quarter-wave element within the operating frequency range and whereby the electromagnetic field is concentrated to the area between the antenna element and its adjacent counterpart, said extra member (10), and to the remaining grounding plane system connected to this, the energy transfer to remaining parts of the portable equipment will be reduced.

4. The method according to claim 1, **characterized in** that said extra member (10) is made as a coaxial conical helix at a lower end of said antenna (1) and being connected to a screen (6) at the antenna coaxial input terminal (4), said extra member inductance in cooperation with present stray capacitances forming a resonance frequency corresponding to a quarter element within the operating frequency range and whereby the electromagnetic field is concentrated to the area between the antenna element and its adjacent counterpart, the extra member (10), and to the remaining grounding plane system connected to that, the energy transfer to remaining parts of the portable equipment will be reduced.

5. An arrangement at an antenna element (1) onto an apparatus in form of a portable equipment comprising a radio transceiver, e.g., in the shape of a pocket telephone, said antenna element having a coaxial input terminal (4) with a sleeve (6) and a central pin (7) and forming a radiator which electrically for example forms a quarter-wave element for the operating frequency range and integrated with an apparatus case (2) there is a grounding plane cooperating with said radiator, **characterized in**

that onto the portion of said coaxial input terminal (4) sleeve (6) being outside said apparatus case (2) is arranged an extra member (10) formed as a coaxial screw shaped line or a helix having a cylindrical shape,

that said extra member (10) additionally forms a portion of the operative grounding plane of said antenna,

that said extra member (10) operates as a resonance circuit, meaning that said member should be tuned to an appropriate frequency in association with the antenna (1) operating frequency range.

6. An arrangement at an antenna element (1) onto an apparatus in form of a portable equipment comprising a radio transceiver, e.g., in the shape of a pocket telephone, said antenna element having a coaxial input terminal (4) with a sleeve (6) and a central pin (7) forming a radiator which electrically for example forms a quarter-wave element for the operating frequency range and integrated with an apparatus case (2) there is a grounding plane cooperating with said radiator, **characterized in**

that onto the portion of said coaxial input terminal (4) sleeve (6) being outside said apparatus case (2) is arranged an extra member (10) formed as a coaxial screw shaped line or helix having a conic shape,

that said extra member (10) additionally forms a portion of the operative grounding plane of said antenna element,

that said extra member (10) operates as a resonance circuit, meaning that said member should be tuned to an appropriate frequency in association with the antenna (1) operating frequency range.

7. The arrangement according to any of claims 5 or 6,
characterized in that said antenna (1) is a compact half-wave antenna, which due to a top loop (1a) attains a rectangular current distribution,

that said extra member (10) is a coaxial outward open helix having a maximum diameter approximately corresponding to the top loop diameter, said arrangement being embedded in an electrically non-conducting material to form an antenna device having the shape of a fustrum of a cone.

8. The arrangement according to any of claims 5, 6 or 7,
characterized in that said extra member (10) is tuned to be resonant preferably near to the upper limiting frequency of a concerned operating frequency range, the rest of said antenna operating grounding plane being preferably tuned to a frequency at the lower limiting frequency of the intended operating frequency range where the portable pocket telephone should operate to thereby further obtain an increased bandwidth and a reduced influence of the immediate surrounding environment for the antenna of the portable equipment.

9. The arrangement according to any of claims 5, 6 or 7,
characterized in that said extra member (10) is tuned in such a manner that it operates as an electric quarter-wave radiator within the range adjacent to the upper limit of an intended operation frequency range, while the rest of said antenna operating grounding plane being tuned to a frequency at or within an adjacent range at the lower limiting frequency of the intended operating frequency range where the

portable pocket telephone should operate to thereby further obtain an increased bandwidth and a reduced influence of the immediate surrounding environment for the antenna of the portable equipment.

10. An antenna device onto a portable equipment comprising a radio transceiver, e.g., in the shape of a pocket telephone, whereby an antenna element (1) is in the shape of an embedded radiator having an essentially rectangular current distribution between a base and a top, and additionally is having a grounding plane cooperating with said antenna element, **characterized in**.

that said antenna device is intended to operate at least within the range 825 - 970 MHz, below at the radiator said device is provided with an extra member (10) connected to the cooperating grounding plane, said extra member having a shape of an open helix comprising preferably four turns and preferably having a maximum diameter of 8 mm and a height of 7 mm and the total embedded antenna device forming a fustrum of a cone having a height of the order 31 mm.

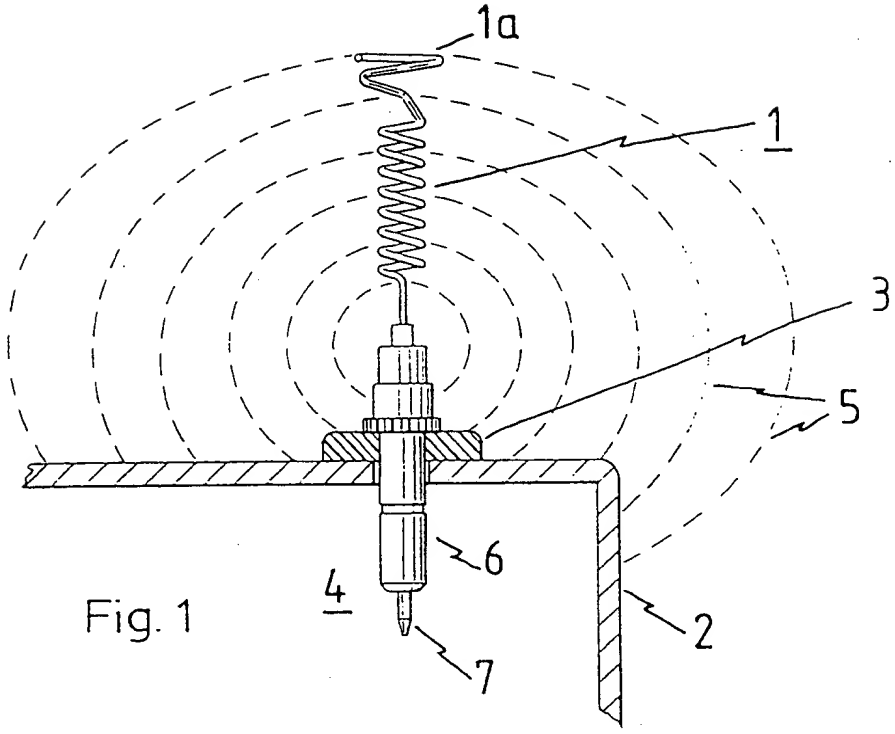


Fig. 1

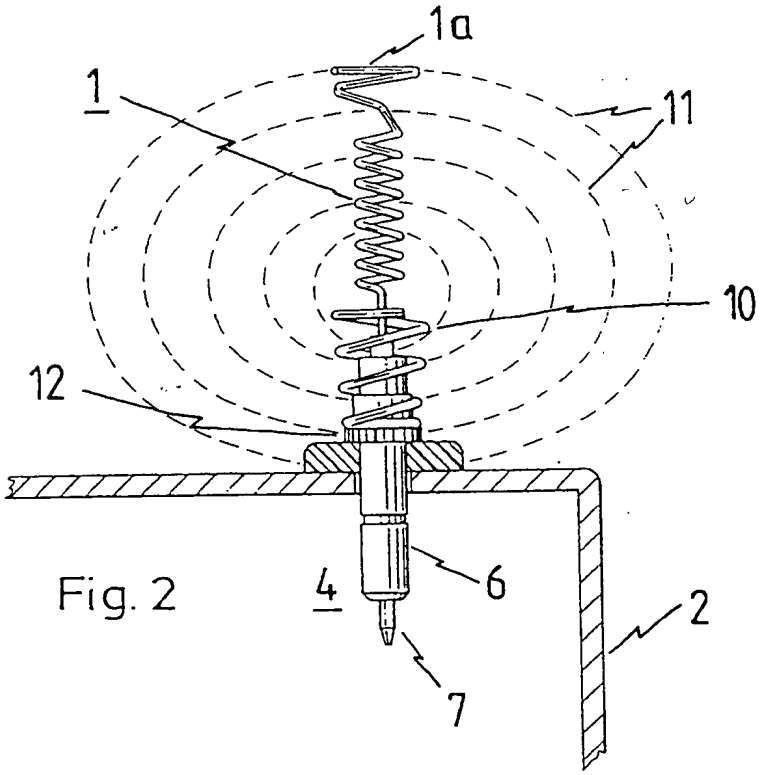
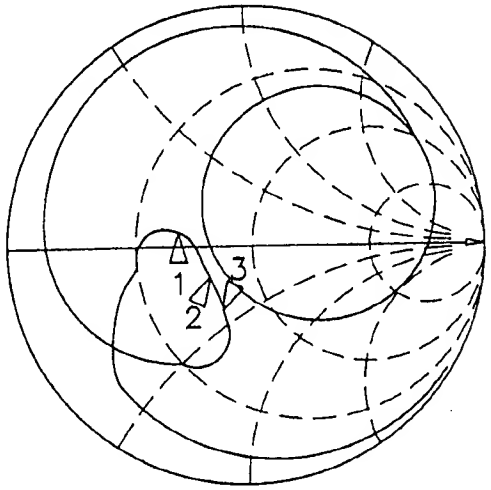


Fig. 2

Fig 3



1. 29.522 Ω
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   825 MHz

2. 40.021 Ω
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   900 MHz

3. 39.236 Ω
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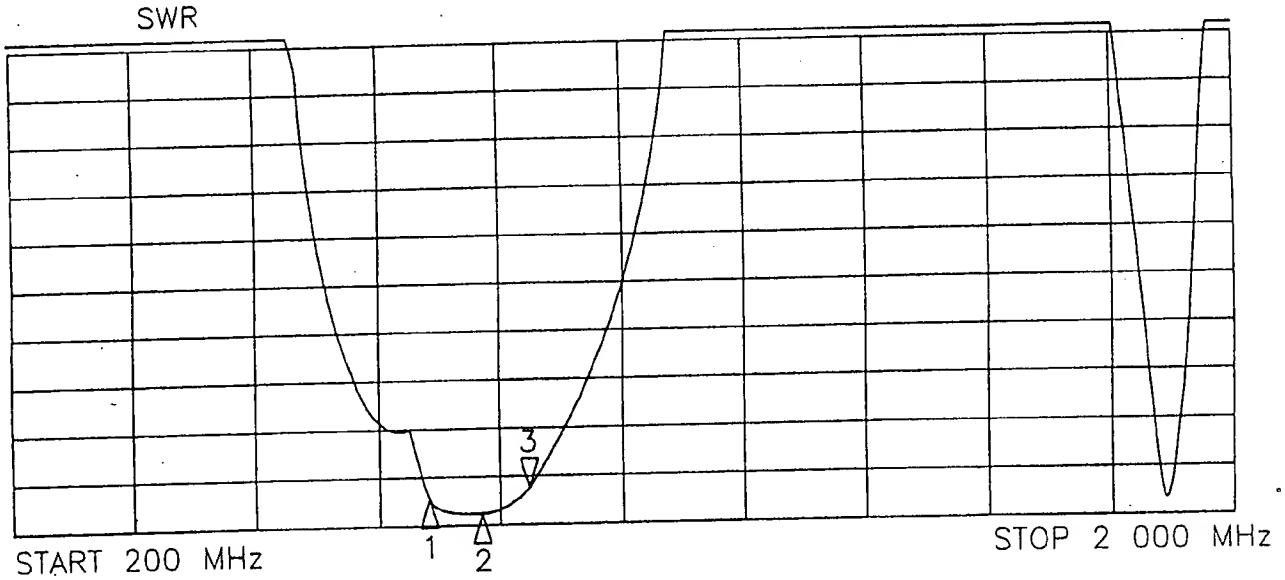
   6.9309 pF
   960 MHz



1. 1.7326
   825 MHz

2. 1.3542
   900 MHz

3. 1.7942
   960 MHz

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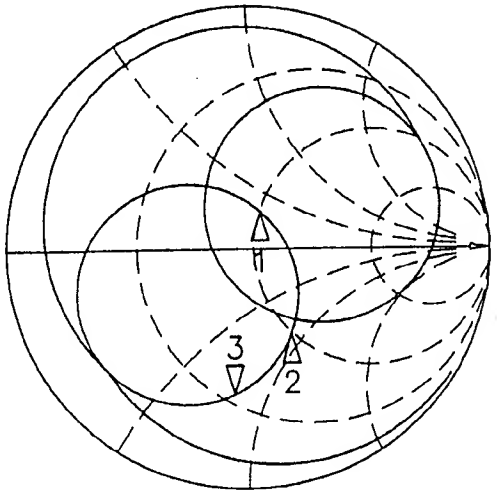
Fig 4



1. 52.473 Ω
   15.119Ω
   825 MHz

2. 50.205Ω
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3. 20.182 Ω
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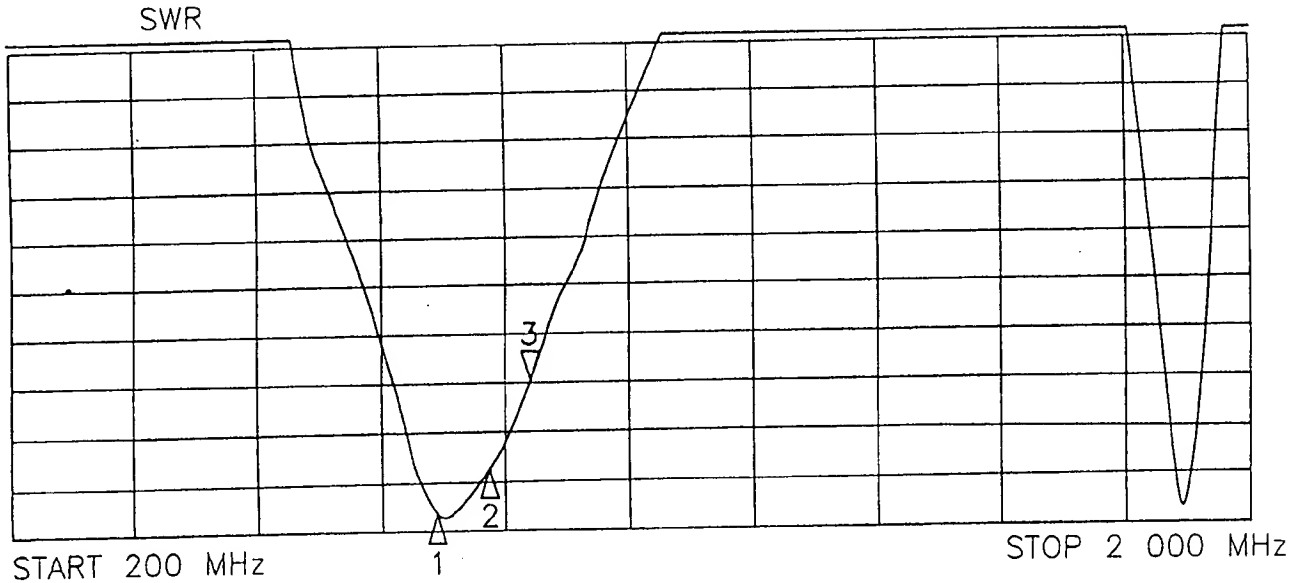

1. 1.3578
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2. 2.3138
   900 MHz

3. 4.0898
   960 MHz

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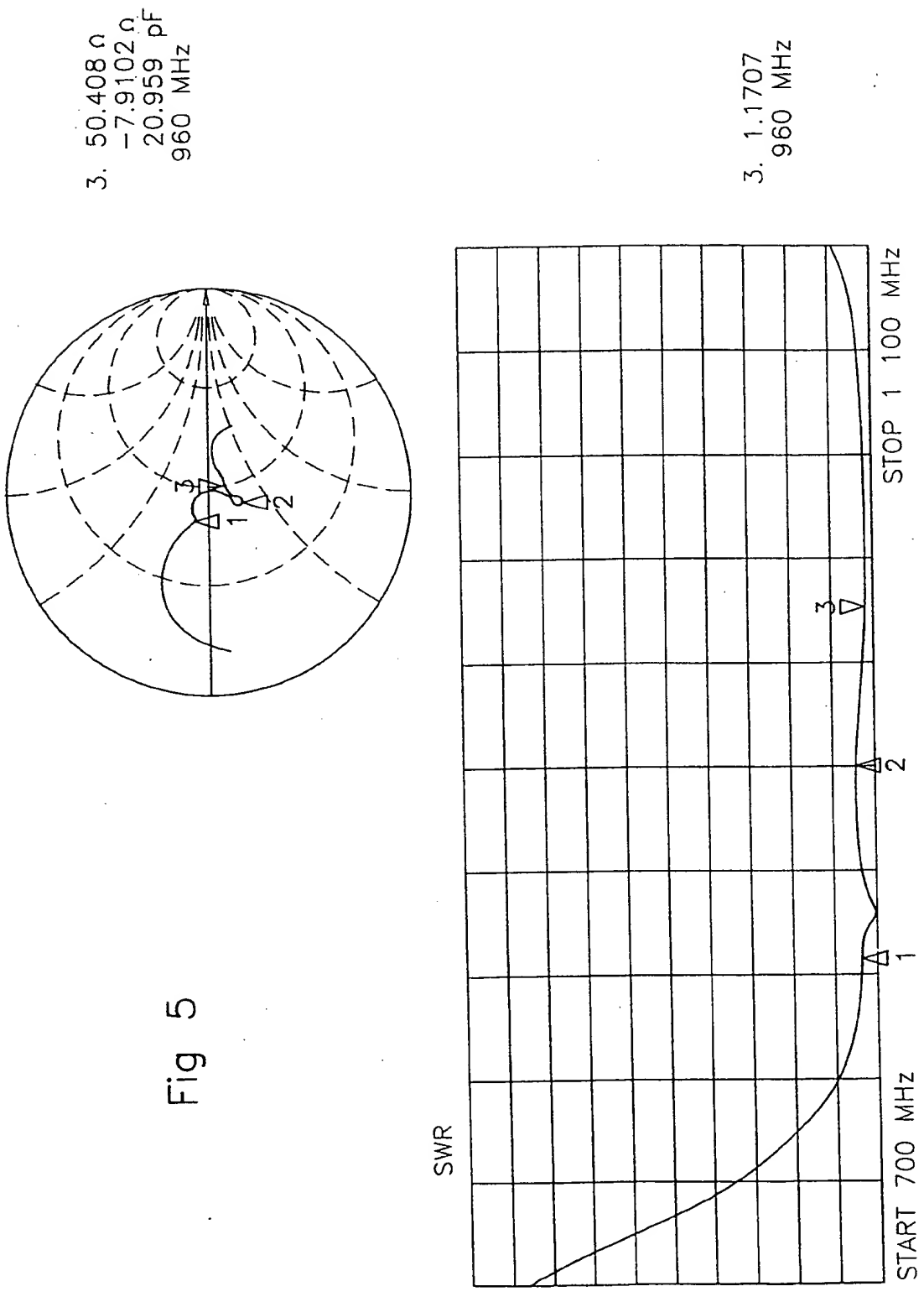
3. 50.408 Ω
−7.9102 Ω
20.959 pF
960 MHz
3. 1.1707
960 MHz
SWR
START 700 MHz
STOP 1 100 MHz
1
2
3

Fig 5

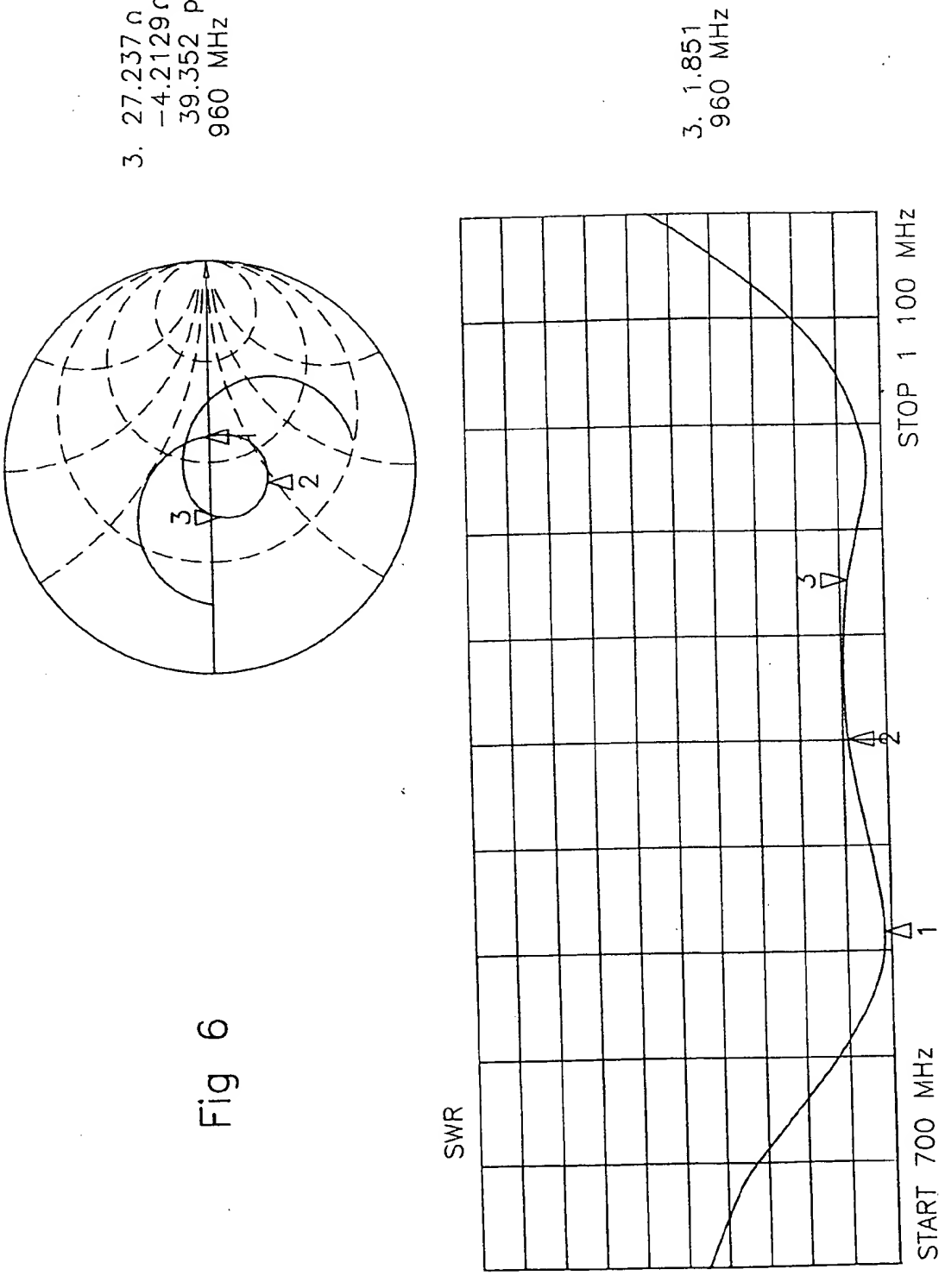
3. 27.237 Ω
−4.2129 Ω
39.352 pF
960 MHz
3. 1.851
960 MHz
SWR
START 700 MHz
STOP 1 100 MHz
1
2
3

Fig 6

European Patent Office

EUROPEAN SEARCH REPORT

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Page 1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	GB, A, 2141878 (NATIONAL RESEARCH DEVELOPMENT CORPORATION), 3 January 1985 (03.01.85) * page 1, line 117 - page 2, line 100, figures 2,3,4 *	1,2,	H01Q 1/27 H01Q 9/38
Y	--	10	
Y	EP, A1, 0528775 (ERICSSON - GE MOBILE COMMUNICATIONS INC.), 24 February 1993 (24.02.93) * see the whole document *	10	
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X	US, A, 4543581 (MIHALY NEMET), 24 September 1985 (24.09.85) * column 4, line 5 - column 6, line 17, figures 6,7,8 *	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
	--		H01Q
X	EP, A2, 0367609 (MOTOROLA, INC.), 9 May 1990 (09.05.90) * column 4, line 6 - column 5, line 1, figure 1 *	1	
	--		
X	US, A, 4138681 (ALLEN L. DAVIDSON ET AL), 6 February 1979 (06.02.79) * column 2, line 47 - column 3, line 27, figure 2 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	7 October 1994	GÖRAN MAGNUSSON

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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